THE AQUATIC PLANT COMMUNITY OF DEEP LAKE, ADAMS COUNTY, WISCONSIN

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I. INTRODUCTION

A field study of the aquatic macrophytes (plants) in Deep Lake was conducted during August 2005 by a staff member of the Adams County Land and Water Conservation Department. Results were shared with the Wisconsin Department of Natural Resources. This was the first aquatic plant survey of any kind done in Deep Lake since 1948.

Information about the diversity, density and distribution of aquatic plants is an essential component in understanding the lake ecosystem due to the integral ecological role of aquatic vegetation in the lake and the ability of vegetation to impact water quality (Dennison et al, 1993). This study will provide information necessary for effective management of Deep Lake, including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulation. This baseline data will provide information that can be used for comparison to future information and offer insight into changes in the lake.

Ecological Role: Lake plant life is the beginning of the lake's food chain, the foundation for all other lake life. Aquatic plants and algae provide food and oxygen for fish and wildlife, as well as cover and food for the invertebrates that many aquatic organisms depend on. Plants provide habitat and protective cover for aquatic animals. They also improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, and impact recreation.

Characterization of Water Quality: Aquatic plants can serve as indicators of water quality because of their sensitivity to water quality parameters such as clarity and nutrient levels (Dennison et al, 1993).

Background and History: Deep Lake, in Adams County, is a 35 surface acre seepage lake formed from historic glacier activity. It has a maximum depth of just over 50'. There are no public boat ramps, although a resort on the east end of the lake has traditionally allowed the public to launch a boat for a small fee from its ramp. The recognized public access is a steep stairway on the south side of the lake that appears to get little use.

The Deep Lake surface watershed is characterized by long steep slopes, so that the lake itself appears to be in a basin. Soils in the watersheds are mostly sand and loamy sand. Predominant land use (nearly one-half) is sparsely-populated forested area, although the ground watershed includes irrigated and non-irrigated agriculture and residential development. Most of the residences around the lake are located at the top of the slopes, so much of the shoreland does have buffer areas of 35' or more. The east end of the lake is the most developed, with a home and several cottages located within less than 70' of water's edge, at nearly water level.

In 1948, a "biological survey" was done on Deep Lake by DNR staff. In that report, Deep Lake was characterized as an infertile lake with moderate to scarce plankton and moderate to sparse aquatic vegetation. Found in abundance were *Potamogeton foliosus and Chara.* Common vegetation included *Elodea canadensis, Najas flexilis, Nuphar advena, Potamogeton amplifolius,* and *Potamogeon friesi. Ceratophyllum demersum, Myriophyllum* spp., *Polygonum* *amphibium, Potamogeton nodosus, Potamogeton zosteriformis, Scirpus validus and Typha latifolia* were all scarce at that time.

There was one chemical treatment of Aquathol on a small area of the lake in 1980, but appears to be no other record for chemical or mechanical treatment for aquatic plant management for this lake.

The Deep Lake fishery is very mixed and includes rainbow and brown trout, largemouth and rock bass, yellow perch, white sucker, northern pike and several panfish such as bluegill, pumpkinseed and green sunfish. Both musk and painted turtles are also found.

There is no Deep Lake organization of any kind.

II. METHODS

Field Methods

The study was based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random transects. The shoreline was divided into 13 equal sections, with a transect placed randomly within each segment, perpendicular to the shoreline.

One sampling site was randomly chosen in each depth zone (0-1.5'; 1.5'-5'; 5'-1, 10'-20') along each transect. Using long-handled, steel thatching rakes, four rake samples were taken at each site. Samples were taken from each quarter around the boat. Aquatic species present on each rake were recorded and given a density rating of 0-5.

A rating of 1 indicates the species was present on 1 rake sample.

A rating of 2 indicates the species was present on 2 rake samples.

A rating of 3 indicates the species was present on 3 rake samples.

A rating of 4 indicates the species was present on 4 rake samples.

A rating of 5 indicates that the species was abundantly present on all rake samples.

A visual inspection and periodic samples were taken between transects to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording plants found.

Shoreline type was also recorded at each transect. Visual inspection was made of 50' to the right and left of the boat along the shoreline, 35' back from the shore (so total view was 100' x 35'). Percent of land use within this rectangle was visually estimated and recorded.

Data Analysis:

The percent frequency (number of sampling sites at which it occurred/total number of sampling sites) of each species was calculated. (See Appendix A) Relative frequency (number of species occurrences/total of all species occurrences) was also determined. (See Appendix A) The mean density (sum of species' density rating/number of sampling sites) was calculated for each species. (See Appendix B) Relative density (sum of species' density/total plant density) was also determined. (See Appendix B) Mean density where present (sum of species' density rating/number of sampling sites at which species occurred) was calculated. (See Appendix B) Relative frequency and relative density for each species were summed to obtain a dominance value. (See

Appendix C). Species diversity was measured by Simpson's Diversity Index. (See Appendix A)

The Average Coefficient of Conservation and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance. A coefficient of conservation is an assigned value between 0 and 10 that measures the probability that the species will occur in an undisturbed habitat. The Average Coefficient of Conservationism is the mean of the coefficients for the species found in the lake. The coefficient of conservatism is used to calculate the Floristic Quality Index, a measure of a plant community's closeness to an undisturbed condition.

An Aquatic Macrophyte Index was determined using the scale developed by Nichols et al (2000). This measurement looks at the following seven parameters and assigns each of them a number on a scale of 1-10: maximum depth of plant growth; percentage of littoral zone vegetated; Simpson's diversity index; relative frequency of submersed species; relative frequency of sensitive species; taxa number; and relative frequency of exotic species. The average total for the North Central Hardwoods lakes and impoundments is between 48 and 57.

III. <u>RESULTS</u>

<u>Physical Data</u>

The aquatic plant community can be impacted by several physical parameters. Water quality, including nutrients, algae and clarity, influence the plant community; the plant community in turn can modify these boundaries. Lake morphology, sediment composition and shoreline use also affect the plant community.

The trophic state of a lake is a classification of its water quality (see Table 1). Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine a trophic state. **Eutrophic lakes** are very productive, with high nutrient levels and large biomass presence. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small fisheries. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; those with a good and more varied fishery than either the eutrophic or oligotrophic lakes.

The limiting factor in most Wisconsin lakes, including Deep Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. Impoundments with over 30 ug/l phosphorus are likely to be subject to nuisance algal blooms. **The 2004-2005 average phosphorus concentration in Deep Lake was 21.37 ug/l.**

Chlorophyll concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth. **The 2004-2005 summer average chlorophyll concentration in Deep Lake was 2.55 ug/l.**

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. **Average summer Secchi disk clarity in Deep Lake in 2004-2005 was 14.34'.**

It is normal for all of these values to fluctuate during a growing season. They can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Phosphorus tends to rise in early summer, than decline as late summer and fall progress. Chlorophyll a tends to rise in level as the water warms, then decline as autumn cools the water. Water clarity also tends to decrease as summer progresses, probably due to algae growth, then decline as fall approaches.

Table 1: Trophic States

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(ug/l)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	**1 to 5**	**8 to 19**
Mesotrophic	Good	**10 to 30**	5 to 10	6 to 8
	Fair	30 to 50	10 to 15	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Deep Lake		**21.37**	**2.55**	**14.34**

According to these results, Deep Lake scores as **"mesotrophic"** in the phosphorus category and an **"oligotrophic"** lake in the chlorophyll a and

Secchi disk categories, with “good” to “very good” water quality. This state would favor low to moderate plant growth and infrequent algal blooms.

Lake morphology is an important factor in distribution of lake plants. Duarte & Kalff (1986) determined that the slope of a littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support higher plant growth than steep sloes (Engel 1985).

Deep Lake is a deep oval-shaped basin with a steeply sloping littoral zone over most of the lake. There are small areas of shallow slopes near the resort and on the southwest side of the lake where a campground is located. The steep slopes do not favor plant growth.

Sediment composition can also affect plant growth, especially those rooted. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a particular lake (see Table 2).

Table 2: Sediment Composition—Deep Lake

Sediment Type		0-1.5'	1.5-5'	5'-10'	10'-20'	All
Hard	Sand	15.39%				3.92%
Sediment	Sand/Rock	7.69%				1.96%
Mixed	Sand/Silt	15.39%				3.92%
Sediment	Sand/Marl	15.38%				3.92%
	Sand/Peat	7.69%				1.96%
	Sand/Muck	15.39%				3.92%
	Peat/Marl	7.69%	23.08%	23.08%	16.67%	17.65%
	Peat/Muck		15.38%			3.92%
	Silt/Marl		7.69%			1.96%
Soft	Marl	7.69%	46.16%	61.54%	83.33%	49.03%
Sediment	Peat	7.69%		15.38%		5.88%
	Muck		7.69%			1.96%

Most of the sediment in Deep Lake is peat or marl or a mixture thereof (see Table 3) that is not supposed to favor strong vegetative growth. However, all the sediment types in Deep Lake supported abundant plant growth, so sediment type does not appear to be a determining factor for plant growth in this lake.

Table 3: Sediment Influence in Deep Lake

Sediment Type		Percent All Sample Sites	Percent Vegetated
Hard	Sand	3.92%	100%
Sediment	Sand/Rock	1.96%	100%
	Sand/Silt	3.92%	100%
	Sand/Marl	3.92%	100%
Mixed	Sand/Peat	1.96%	100%
Sediment	Sand/Muck	3.92%	100%
	Peat/Marl	17.65%	100%
	Peat/Muck	3.92%	100%
	Silt/Marl	1.96%	100%
Soft	Marl	49.03%	100%
Sediment	Peat	5.88%	100%
	Muck	1.96%	100%

Shoreline land use often strongly impacts the aquatic plant community and thus the entire aquatic community. Impacts can be caused by increased erosion and sedimentation and higher run-off of nutrients, fertilizers and toxins applied to the land. Such impacts occur in both rural and residential settings.

Both wooded and herbaceous vegetation were found at 100% of the transects (see Table 4, with shrub vegetation less common. Disturbed sites, such as those with hard structures, rock/riprap and pavement, were not frequently found. The most commonly encountered hard structure was piers.

Table 4: Shoreland Land Use—Deep Lake

Cover Type		Occurrence frequency at transects	Percent Coverage
Vegetated	Wooded	100.00%	43.9%
Shoreline	Herbaceous	100.00%	26.2%
	Shrubs	61.54%	11.5%
Disturbed	Cultivated Lawn	15.38%	4.6%
Shoreline	Hard Structures	61.54%	7.3%
	Rock/riprap/pavement	30.77%	3.0%
	Bare Sand	38.46%	3.5%

Perhaps due to the long steep slopes, traditional lawn was not often found and covered little of the shoreline. Vegetation covered 81.6% of the shoreline.

Macrophyte Data

SPECIES PRESENT

Of the 23 species found in Deep Lake, seven were emergent, one was a floating-leaf rooted plant, and fourteen were submergent types (see Table 5).

One plant-like algae, Chara spp., was also found at nearly all sample sites. No free-floating plant species were found. No endangered or threatened species were found. One exotic invasive, *Phalaris arundinacea* (reed canarygrass), was found at one transect.

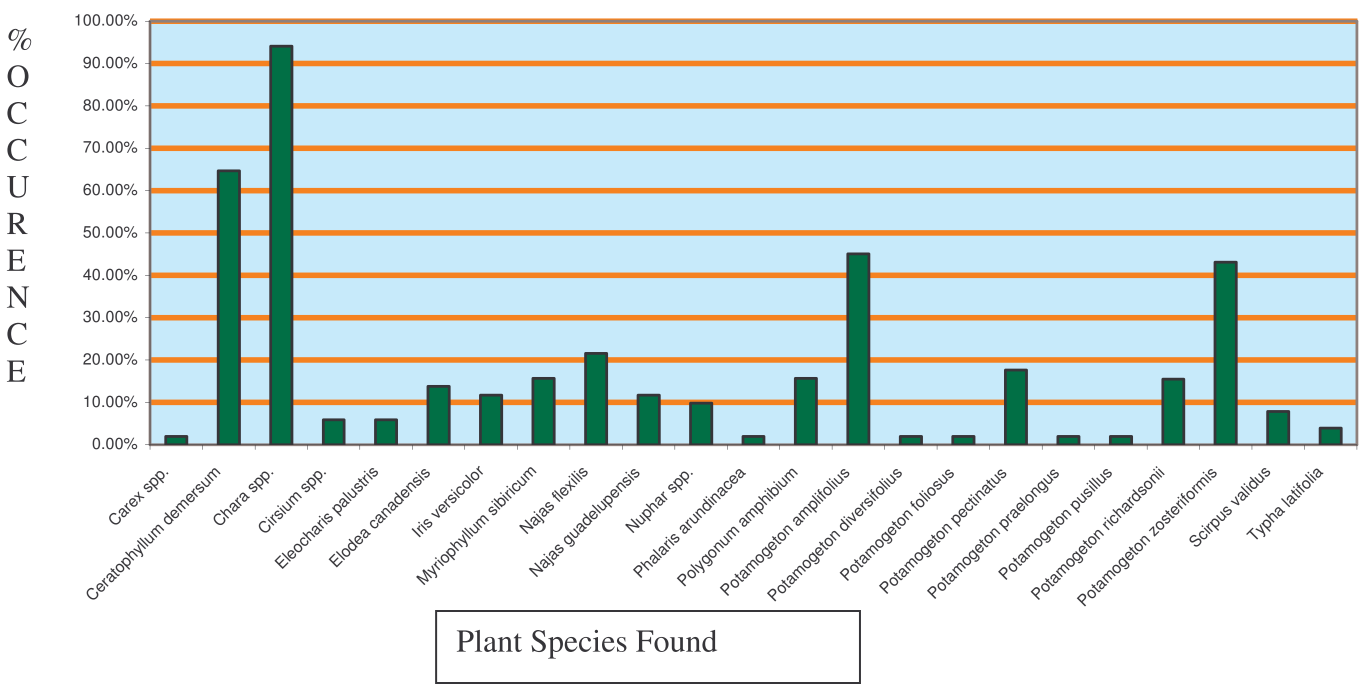
Table 5—Plants Found in Deep Lake, 2005

Scientific Name			Common Name
Emergent Species			
Carex spp.			sedge
Cirsium spp.			thistle
Iris versicolor			blue flag iris
Phalaris arundinacea			reed canarygrass
Polygonum amphibirum			water smartweed
Scirpus validus			soft-stem bulrush
Typha latifolia			narrow-leaf cattail
Floating-Leaf			
Nuphar spp			yellow pond lily
Submergent Species			
Ceratophyllum demersum			coontail
Eleocharis palustris			creeping spikerush
Elodea canadensis			common waterweed
Myriophyllum sibircum			northern watermilfoil
Najas flexilis			bushy pondweed
Najs guadelupensis			southern naiad
Potamogteon amplifolius			large-leaf pondweed
Potamogeton diversifolius			variable-leaf pondweed
Potamogeton foliosus			leafy pondweed
Potamogeton pectinatus			sago pondweed
Potamogeton praelongus			white-stem pondweed
Potamogeton pusillus			small pondweed
Potamogeton richarsonii			clasping-leaf pondweed
Potamogton zosteriformis			flat-stem pondweed
Plant-like Algae			
Chara spp.			muskgrass

FREQUENCY OF OCCURRENCE

Ceratophyllum demersum was the most frequently occurring plant species in Deep Lake (64.71%), although *Chara* was the most frequently-occurring aquatic species. *Potamogeton amplifolius* and *Potamogeton zosteriformis* were the next most frequently-occurring plants in Deep Lake in 2005 (with 45% and 43% respectively). *Chara* spp. was found at over 94% of the sample sites.

Figure 1: Frequency of Occurrence

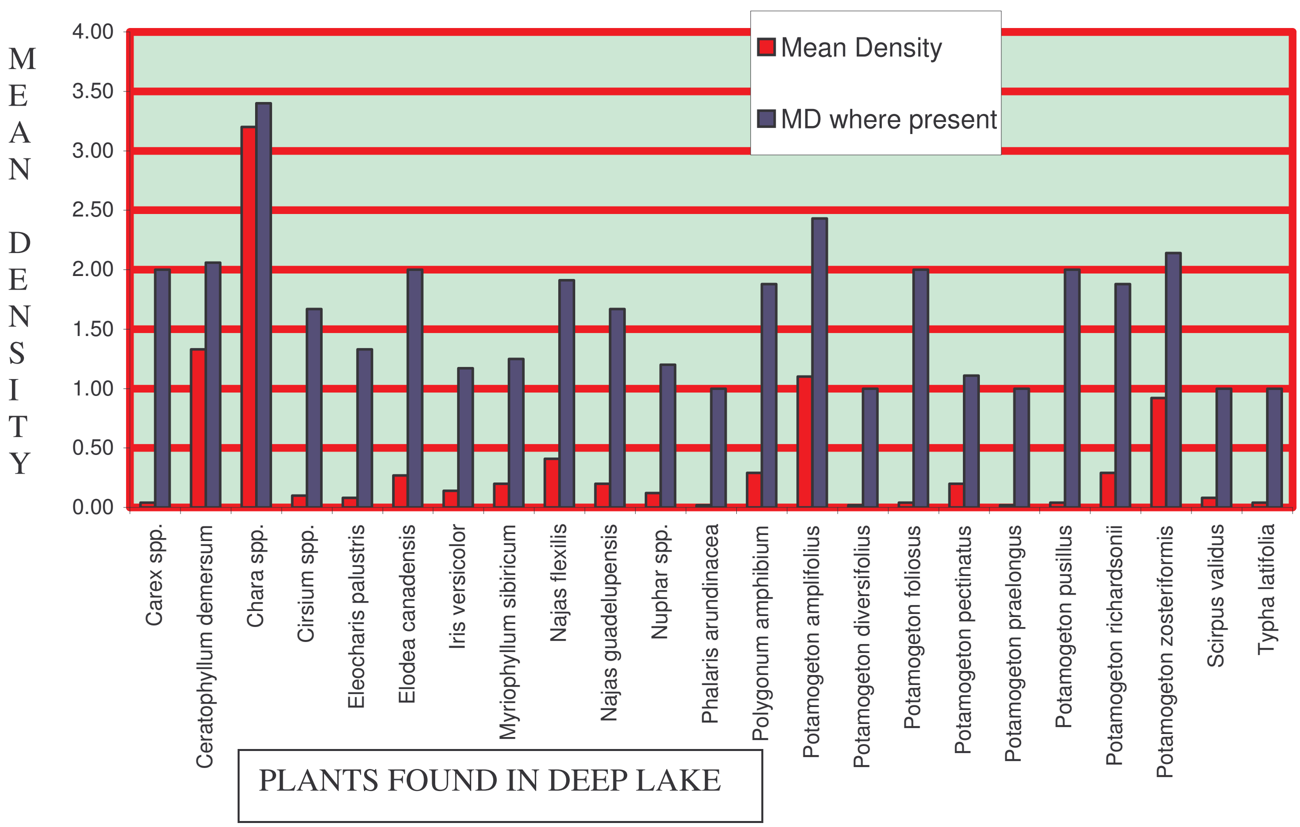


Filamentous algae was present at just over 21% of the sample sites. It occurred at 46% of the 0-1.5’ depth; at 15% of the 1.5’-5’ depth sites; and 23% of the 5’-10’ depth. It wasn’t found at any of the deepest sample sites. Coating of plant leaves by calcium deposits was also noted.

DENSITY OF OCCURRENCE

Chara spp. was the aquatic species with the highest mean density (3.2). The plant species with the highest mean density in Deep Lake were *Ceratophyllum demersum* (1.33 on a scale of 1-5), *Potamogeton amplifolius* 1.10) and *Potamogeton zosteriformis* (.92). (See Figure 2)

Figure 2: Mean Density



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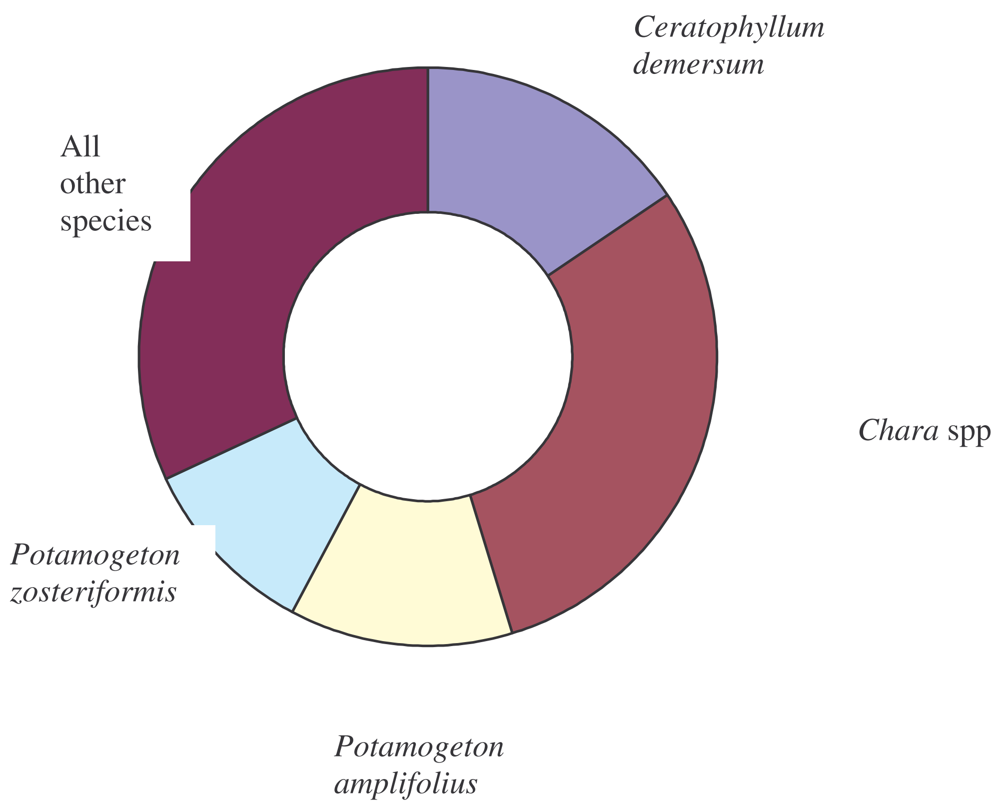
The situation is different when “mean density where present” is evaluated. Chara spp., Ceratophyllum *demersum, Potamogeton amplifolius, Potamogeton praelongus* and *Potamogeton richardsonii* all had “mean density where present” results over 2.0, with *Chara* having the highest. This means that where these plants and algae occurred, they had a growth form above average density.

DOMINANCE

Relative frequency and relative density are combined into a dominance value that demonstrates how dominant a species is within its aquatic plant community. Based on dominance value, *Chara* spp. was the dominant aquatic species in Deep Lake (see Figure 3). The dominant plant specie was *Ceratophyllum demersum*. *Potamogeton amplifolius* and *Potamogeton zosteriformis* were sub-dominant overall. The exotic species found, *Phalaris arundinacea*, did not have high dominance in the aquatic plant community.

Figure 3: Dominance



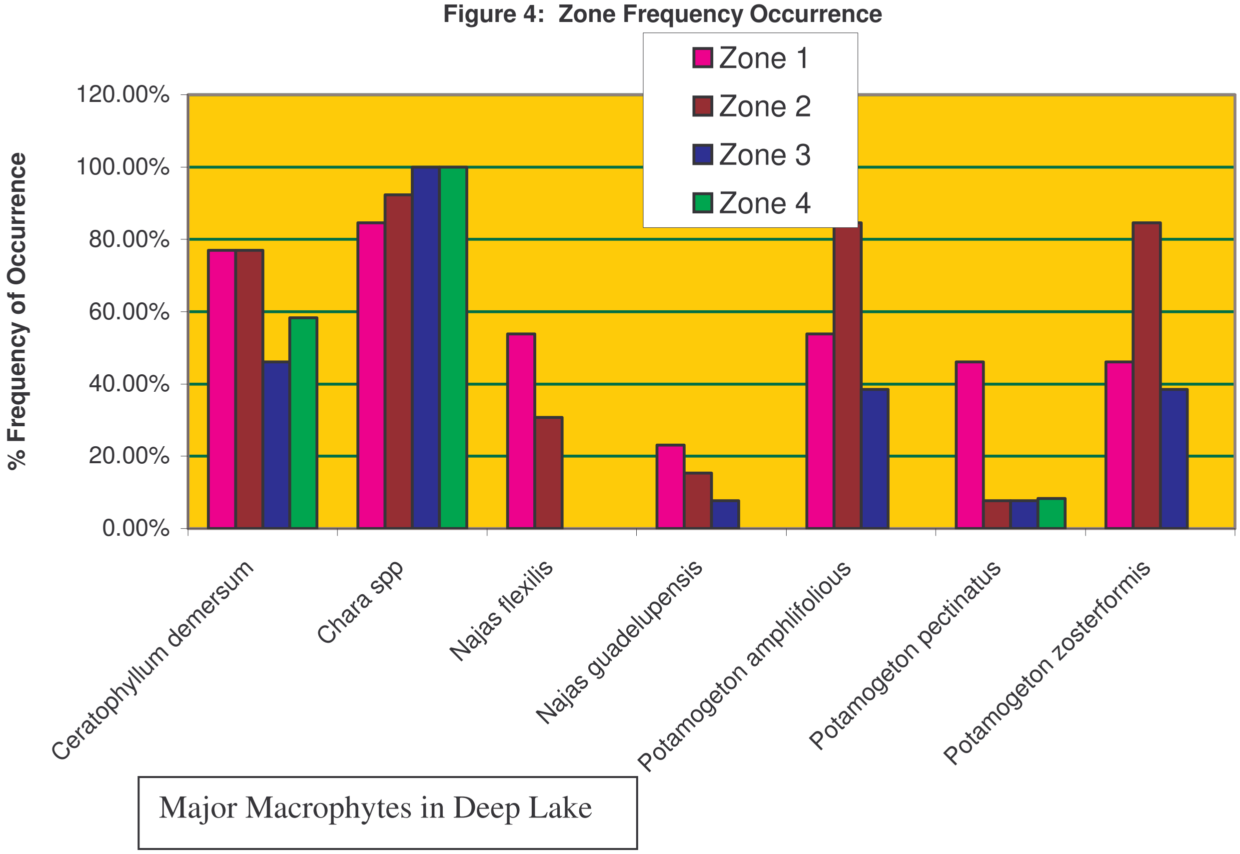
Chara spp. dominated the aquatic vegetation in all depth zones. *Ceratophyllum demersum* was the dominant aquatic plant in three of the four depth zones. In

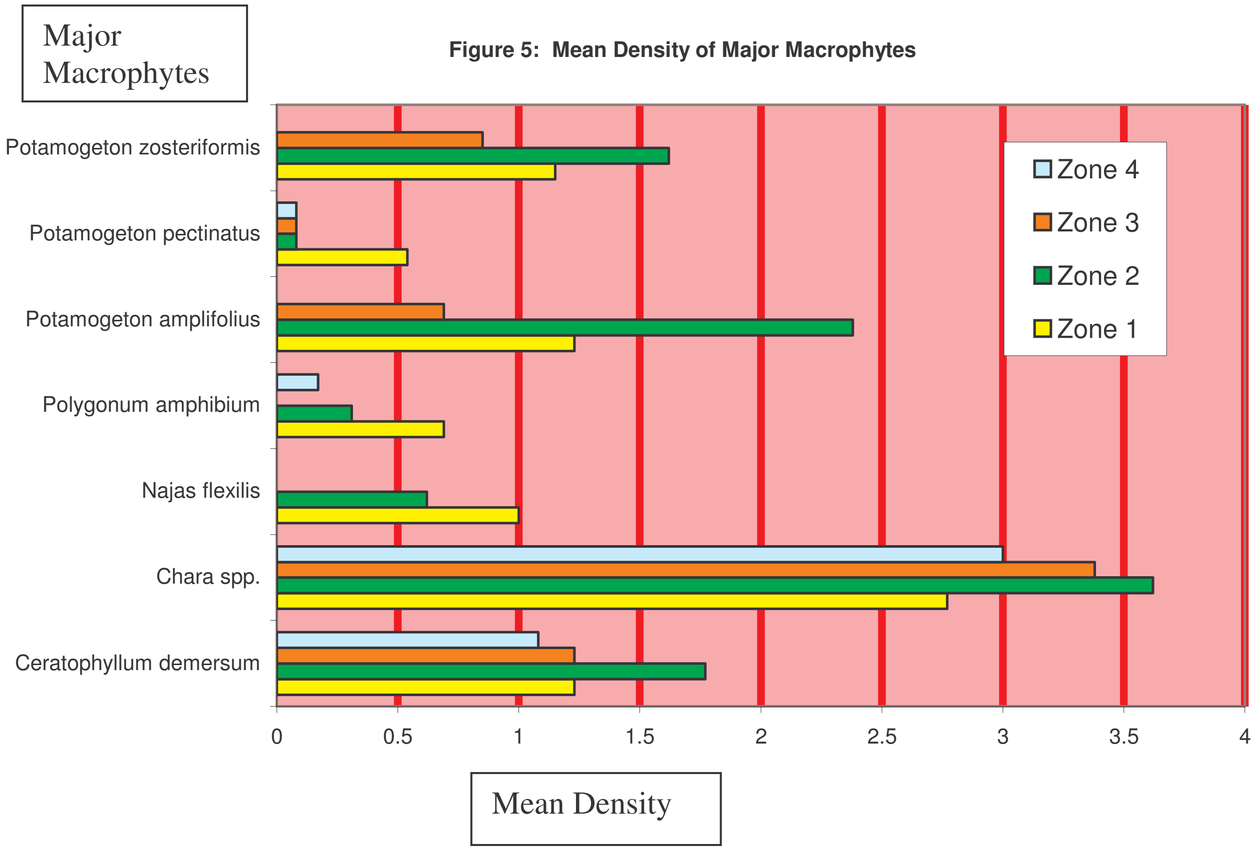
Zone 1 (0-1.5’), *Najas flexilis* and *Potamogeton amplifolius* were subdominant. *Potamogeton amplifolius* and *Potamogeton zosteriformis* were dominant in Zone 2 (1.5’-5’), while *Ceratophyllum demersum* was subdominant. In Zone 3 (5’-10’), *Potamogeton amplifolius* and *Potamogeton zosteriformis* were sub-dominant. In Zone 4 (10’-20’), *Potamogeton richardsonii* was subdominant.

DISTRIBUTION

Aquatic plants occurred in nearly all Deep Lake, with 100% of the sample sites vegetated (see Figures 4 and 5).

Figure 4: Zone Frequency Occurrence





Secchi disc readings are used to predict maximum rooting depth for plants in a lake (Dunst, 1982). Based on the summer 2004-2005 Secchi disk readings, the predicted maximum rooting depth in Deep Lake would be **25.1 feet.** The aquatic plant survey results are in agreement with this predicted depth, i.e., this calculation suggests that rooted plants at all depths would be anticipated in this lake, and rooted plants were found at all depths in Deep Lake.

The 0-1.5' depth zone (Zone 1) produced the greatest amount of plant growth with the highest total occurrence. Zones 1 (0-1.5') and 2 (1.5'-5') had nearly the same plant density (see Figures 6 and 7). Zone 3 (5'-10') and Zone 4 (10'-20') both recorded much lower occurrence and density.

Figure 6: Overall Frequency of Occurrence

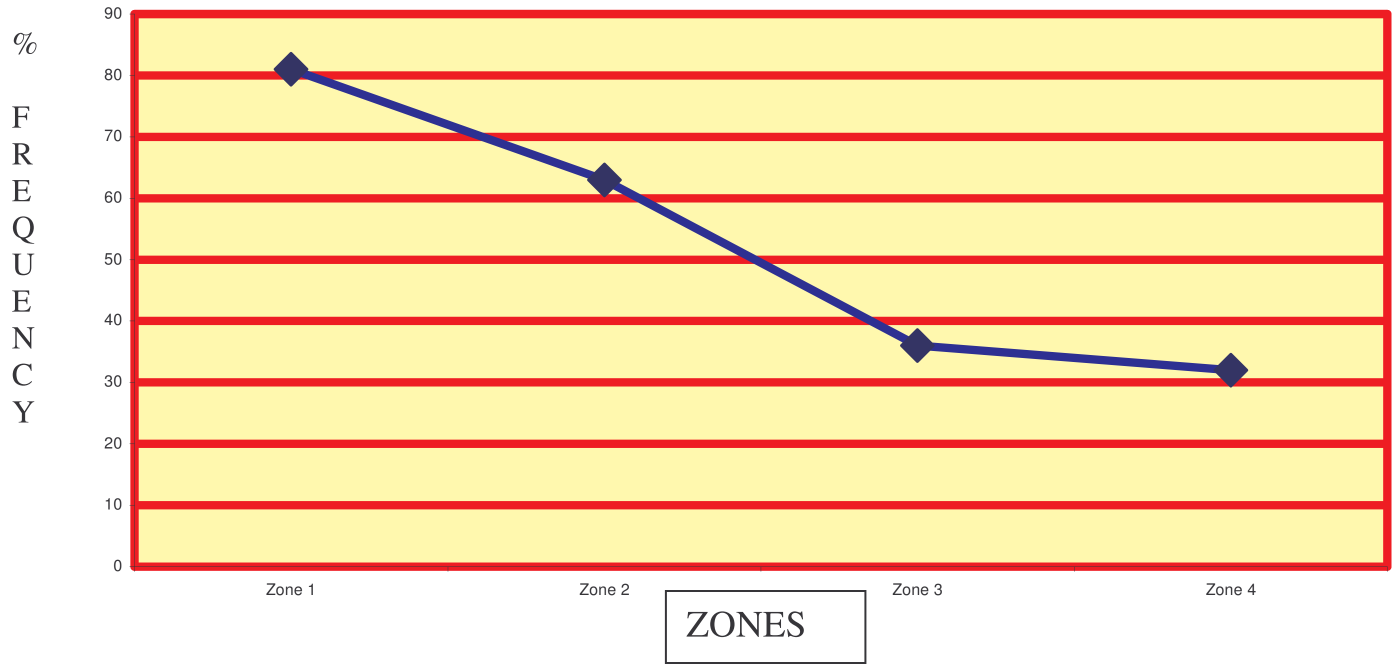
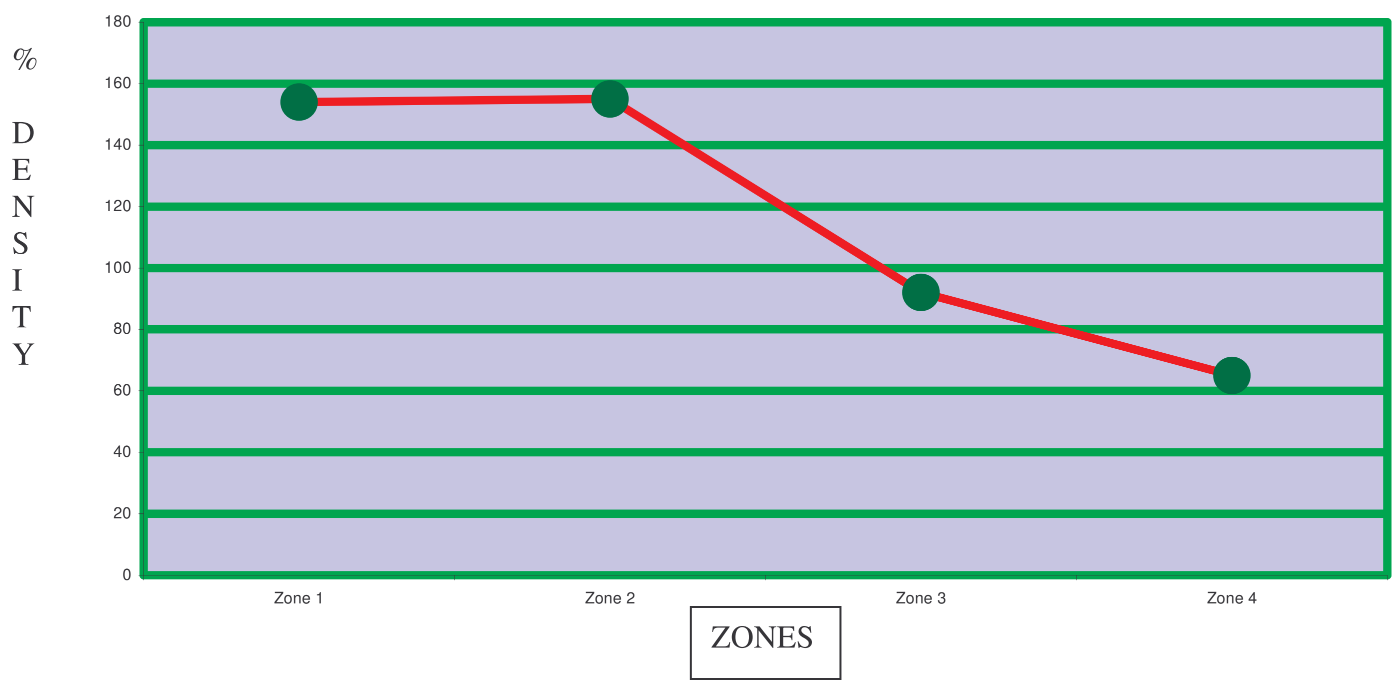


Figure 7: Overall Density



100% of the sites in all zones were vegetated. The greatest mean number of species per site (species richness) was found in Zone 1, with a 6.23 richness score. Zone 2 had a richness score of 4.85. Zone 3 had a richness score of 2.77, while Zone 4 had a richness score of 2.67. Overall mean richness was 4.16.

THE COMMUNITY

The Simpson's Diversity Index for Deep Lake was .89, suggesting good species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). The Aquatic Macrophyte Community Index (AMCI) for Deep Lake is 58. This is in the upper quartile for Central Wisconsin Hardwood Lakes and Impoundments and all Wisconsin lakes.

The only invasive now present in Deep Lake is *Phalaris arundinacea* (reed canarygrass). Currently, its density and frequency is low in Deep Lake's aquatic plant community, but its tenacity and ability to spread to large areas fairly quickly make it a danger to the diversity of Deep Lake's aquatic plant community.

A Coefficient of Conservatism and a Floristic Index Quality calculation were performed on the field results. Technically, the average Coefficient of Conservatism measures the community's sensitivity to disturbance, while the Floristic Index measures the community's closeness to an undisturbed condition. Indirectly, they measure past and/or current disturbance to the particular community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservation for Deep Lake was 5.24. This indicates that the current aquatic plant community in Deep Lake is slightly below the average for Wisconsin Lakes (6.0) and for lakes in the North Central Hardwood Region (5.6). The current aquatic plant community appears to have started to respond to some past disturbances, but has not yet been heavily impacted by them.

The Floristic Quality Index of the aquatic plant community in Deep Lake of 24+ is above average for Wisconsin Lakes (22.2) and in the upper quartile for lakes in the North Central Hardwood Region (20.9). This indicates that the plant community in Deep Lake is in the group of lakes closest to an undisturbed condition in Wisconsin overall and in the North Central Hardwood Region. In other words, the aquatic plant community in Deep Lake appears not to have been significantly impacted by a high amount of disturbance.

Steps may need to be taken to maintain this situation. Recently, the owner of the west end of the lake, which has been largely untouched, applied to the Adams County Planning & Zoning Department for permission to develop the area into smaller lots. This development would negatively impact the aquatic plant community and the water quality. Also, the small resort on the east end of the lake is up for sale. Purchase by an aggressive owner that develops the site to more "modern" conditions could also negatively impact the watershed and the aquatic plant community.

"Disturbance" is a term that covers many disruptions to a natural community. It includes physical disturbances to plant beds such as boat traffic, plant harvesting, chemical treatments, dock and other structure placements, shoreline development and fluctuating water levels. Indirect disturbances like sedimentation, erosion, increased algal growth, and other water quality impacts will also negatively affect an aquatic plant community. Biological disturbances such as the introduction of non-native and/or invasive species, destruction of plant beds, or changes in aquatic wildlife can also decrease an aquatic plant community. If, for example, the resort boat ramp is "modernized" and traffic increases, that will disturb the current aquatic plant community and also increase the likelihood that invasive species will arrive in Deep Lake.

IV. <u>DISCUSSION</u>

Based on water clarity, chlorophyll and phosphorus data, Deep Lake is a mesotrophic (phosphorus) to oligotrophic (chlorophyll a and Secchi disc) natural lake with good to very good water clarity and water quality. This trophic state should support low to moderate plant growth and infrequent algal blooms.

100% of the lake sample sites were vegetated, but aquatic plants do not appear to be over-abundant. This is probably due to the narrow littoral zone caused by the steep drop-offs to depth greater than the photic zone and to the sediment types (peat and marl) that don't have high nutrient loads and/or are loose in texture, making plant establishment difficult. Deep Lake has no recorded history of chemical or mechanical treatment for aquatic plant management, but could likely benefit from the development of an aquatic plant and/or lake management plan that includes monitoring the aquatic plants on a regular schedule. Monitoring is essential to maintain the high community quality and, hopefully, to catch any invasive plants that may get introduced before they get established and negatively impact the current above-average plant community. However, developing a lake management plan will require the formation of some kind of lake organization for Deep Lake, since none currently exists.

Aquatic vegetation occurred at 100% of the sample sites, with 100% of the sites also having rooted aquatic plants. Athough this is technically above the preferred range (50%-85%) for a balanced fishery, the lake does still have a large area (deeper than 20’) that is not populated by with aquatic plants. Further, the surveyed littoral zone was very narrow and did not appear to have over-abundant aquatic vegetation. Citizen reports do suggest a diversity of fish is present in Deep Lake.

The lake has mostly a mixture of emergent and submergent plants. Of the 22 plant species recorded in Deep Lake in summer 2005, 7 were emergent, 1 was floating-leaf and the remaining 14 were rooted. The free-floating plant species such as *Lemna minor, Spirodela polyrhiza* and *Wolffia* spp., often indicative of reduced water quality, were not found in Deep Lake.

The aquatic plant community in Deep Lake is quite varied. Of the 23 species found, only *Ceratophyllum demersum, Potamogeton amplifolius and Potamogeton zosteriformis* were found frequently enough to be called "abundant" (over 50% frequency). The macrophyte algae, *Chara* spp., was "very abundant." Luckily, *Phalaris arundinacea* (reed canarygrass) currently doesn't show mean density and relative frequency to establish it as dominant among Deep Lake's aquatic plant community, its tenacity and ability to spread to large areas fairly quickly make it a danger to the diversity of Deep Lake's aquatic plant community. Targeting this plant by specific plant management techniques may help keep its spread in check.

The Simpson's Diversity Index for Deep Lake was .89, suggesting good species diversity. The Aquatic Macrophyte Community Index (AMCI) for Deep Lake is 58 (see Table 6), indicating an about average quality aquatic plant community. The 5.04 Average Coefficient of Conservation score puts Deep Lake near the average of Wisconsin lakes and lakes in the North Central Hardwood Region. The aquatic plant community in Deep Lake is in the category of farther from disturbance than the average lake in Wisconsin.

Table 6: Aquatic Macrophyte Community Index

Aquatic Macrophyte Community Index for Deep Lake		
Category	Deep Lake results	Value
Maximum rooting depth	7+ meters	10
% littoral area vegetated	100%	10
%submersed plants	65.7%	7
% sensitive plants	21.7%	8
# taxa found	23 (1 exotic)	9
exotic species frequency	.5%	6
Simpon's Diversity	0.89	8
total		**58**

The Floristic Quality Index of the aquatic plant community in Deep Lake of 54.32 is in the highest quartile of for Wisconsin Lakes and lakes in the North Central Hardwood Region. This indicates that the plant community in Deep Lake is among the group of lakes closest to an undisturbed condition. This suggests that the aquatic plant community in Deep Lake has not been significantly impacted by a high amount of disturbance.

Wooded vegetation and herbaceous vegetation were found at 100% in Deep Lake shorelines. Wooded vegetation had the highest coverage (nearly 44%), and herbaceous vegetation covered only 26% of the shoreline. Some type of disturbed shoreline was found at 69% of the sites, and it covered 18.46% of the shoreline. Disturbed shorelines offer little protection for water quality and have significant potential to negatively impact Deep Lake's water quality and plant community. They also can negatively affect fish and wildlife habitat in and around the lake. Deep Lake can hopefully keep its near-undisturbed quality. Expanding the amount of natural vegetation at the shoreline, especially with wider buffers in disturbed areas, would help maintain the current condition and help prevent erosion and reduce runoff into the lake that could contribute to algal growth, increased sedimentation, and reduced water quality.

V. CONCLUSIONS

Deep Lake is a mesotrophic to oligotrophic lake with good to very good water quality and clarity. Its steeply-sloping deep basin doesn't highly favor plant growth. The aquatic plant community in Deep Lake ranks in the highest quartile for Wisconsin lakes and for lakes in the North Central Hardwood region. Structurally, it contains emergent plants, rooted plants, and one rooted plant with floating leaves. The community is characterized by plants that do not tolerate a high amount of disturbance. Filamentous algae is abundant in the shallowest zone and common in the other three depth zones.

When the aquatic plant survey was performed, 100% of the lake was vegetated. The potential for plant growth, especially dense growth, in the littoral zones of the lake is limited due to the sediment types and steep sharp dropoffs in depth. There may be some on-going nutrient input into the lake from the groundwatershed, which is 22% irrigated agriculture and 4% general agriculture, but it would move slowly towards the lake. There is no creek coming into Deep Lake that would cause higher on-going nutrient input (see Appendix F).

The most frequent and most dense plant in the lake was *Ceratophyllum demersum* (coontail), a rooted plant. The next closest plants in frequency were *Potamogeton zosteriformis* (flat-stemmed pondweed, a rooted plant) and *Potamogeton amplifolius* (large-leaf pondweed, a rooted plant). Chara spp., a plant-like algae, was both frequent and above-average density.

Dominant in all three of the four depth zones was *Ceratophyllum demersum*. *Potamogeton amplifolius and Najas flexilis* were sub-dominant in the 0-1.5' depth, while *Potamogeton amplifolius* and *Potamogton zosteriformis* were sub-dominant in the 1.5'-5' depth zone and the 5'-10' depth zone. Subdominant in the 10'-20' depth zone was *Potamogeton richardsonii.*

A healthy and diverse aquatic plant community plays a vital role within the lake ecosystem. Plants help improve water quality by trapping nutrients, debris and pollutants in the water body; by absorbing and/or breaking down some pollutants; by reducing shore erosion by decreasing wave action and stabilizing shorelines and lake bottoms; and by tying-up nutrients that would otherwise be available for algae blooms. Aquatic plants provide valuable habitat resources for fish and wildlife, often being the base level for the multi-level food chain in the lake ecosystem, and also produce oxygen needed by animals.

Further, a healthy and diverse aquatic plant community can better resist the invasion of species (native and non-native) that might otherwise "take over" and create a lower quality aquatic plant community. A well-established and diverse plant community of natives can help check the growth of more tolerant (and less desirable) plants that would otherwise crowd out some of the more sensitive species, thus reducing diversity.

Vegetated lake bottoms support larger and more diverse invertebrate populations that in turn support larger and more diverse fish and wildlife populations (Engel, 1985). Also, a mixed stand of aquatic macrophytes (plants) supports 3 to 8 times more invertebrates and fish than do monocultural stands (Engel, 1990). A diverse plant community creates more microhabitats for the preferences of more species.

MANAGEMENT RECOMMENDATIONS

Aquatic plant management in Deep Lake should focus mostly on maintaining the already high-quality aquatic plant community.

(1) Some kind of Deep Lake organization needs to be formed to help maintain the high-quality status of this lake.

(2) Because the plant cover in the littoral zone of Deep Lake is over the ideal (25%-85%) coverage for balanced fishery, the deeper areas of the lake should be evaluated to make sure that they even out the vegetated/non-vegetated balance.

(3) Sensitive areas need to be identified on the lake so that they can be protected in the future to protect diversity and habitat.

(4) Care, through use of zoning regulations, needs to be taken that potential development on the far east and west ends of the lake do not occur in a way that negatively impacts the aquatic plant community and the water quality.

(5) Natural shoreline restoration is needed. The disturbed shorelines that cover some of the current shoreline could be improved by a buffer area of native plants, especially on those sites that now have traditional lawns mowed to the water's edge.

(6) No lawn chemicals, especially lawn chemicals with phosphorus, should be used on properties around the lake. If they must be used, they should be used no closer than 50' to the shore.

(7) An aquatic plant management plan should be developed with a regular schedule, with emphasis on maintaining the high-quality aquatic plant community. Such plans will be required by the Wisconsin DNR for aquatic plant permits and grants and will also assist in preventing any increase in the frequency and density of the plants in Deep Lake.

(8) The plan should include scheduled on-going monitoring for increased plant frequency/density and for the introduction of any invasive species.

(9) No broad-scale chemical treatments of aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material and opening up more areas to the invasive plants.

(10) Although Adams County Land & Water Conservation Department currently takes regular surface water samples, the program only goes through 2006. Deep Lake residents should get involved in the Wisconsin Self-Help Monitoring Program to permit on-going monitoring of the lake trends for little cost.

(11) Deep Lake residents should identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs.

LITERATURE CITED

Dennison, W., R. Orth, K. Moore, J. Stevenson, V. Carter, S. Kollar, P. Bergstrom and R. Batuik. 1993. Assessing water quality with submersed vegetation. BioScience 43(2):86-94.

Duarte, Carlos M. and Jacob Kalff. 1986. Littoral slope as a predictor of the maximum biomass of submerged macrophyte communities. Limnol.Oceanogr. 31(5):1072-1080.

Dunst, R.C. 1982. Sediment problems and lake restoration in Wisconsin. Environmental International 7:87-92.

Engel, Sandy. 1985. Aquatic community interactions of submerged macrophytes. Wisconsin Department of Natural Resources, Technical Bulletin #156. Madison, WI.

Gleason, H, and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada (2nd Edition). New York Botanical Gardens, N.Y.

Jessen, Robert, and Richard Lound. 1962. An evaluation of a survey technique for submerged aquatic plants. Minnesota Department of Conservation. Game Investigational Report No. 6.

Nichols, Stanley. 1998. Floristic quality assessment of Wisconsin lake plant communities with example applications. Journal of Lake and Reservoir Management 15(2):133-141.

Nichols, S., S. Weber and B. Shaw. 2000. A proposed aquatic plant community biotic index for Wisconsin lakes. Environmental Management 26(5):491-502.

Shaw, B., C. Mechenich and L. Klessig. 1993. Understanding Lake Data. University of Wisconsin-Extension. Madison, WI.